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ABSOLUTE GRAVITY MEASUREMENTS IN THE UNITED STATES OF AMERICA.(U)
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6 ABSOLUTE GRAVITY MEASUREMENTS IN THE UNITED STATES OF AMERICA.

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The measurements of gravity acceleration described in the report were performed in 1980 within a grant program sponsored by the US Air Force. The introductory part of the report illustrates the transportable absolute gravimeter and ancillary instrumentation used in measurements, and describes the measurement method applied; uncertainty and errors are analysed as well. Measurements of gravity acceleration made in Europe prior to the USA program are also briefly considered before a detailed account is given of the measurements made in the USA. The numerous tables in the text and at the end of the report form an		

essential part of it. Six stations were observed in the USA and approximately 100 measurements made per station. The results show an overall uncertainty in g measurements of the order of 10 μ Gal.

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The work described in this final report was developed in the framework of an international grant programme for basic research of the US Air Force Office of Scientific Research, grant n° AFOSR-80-0157.

For the realization of the programme contributions were given by

- Italy : A. Bray, contractor representative, Director of the Istituto di Metrologia "G. Colonnetti" (IMGC), Torino; G. Cerutti, physicist, main investigator, researcher at IMGC; I. Marson, physicist, principal investigator, assistant professor at the University of Trieste; L. Cannizzo, higher-grade technician at IMGC; F. Alasia, higher-grade technician at IMGC.
- U.S.A. : B. Szabo, programme manager, Senior Scientist at the Terrestrial Sciences Division, Air Force Geophysical Laboratory (AFSC), Hanscom AF Base; W. Spita, gravimetrist, Geodetic Survey Squadron, DMATC, Warren AFB, Wyoming; J. Hammond, physicist, Geodesy & Gravity Branch, Terrestrial Sciences Division AFGL.

Measurements in USA were carried out by I. Marson, F. Alasia, W. Spita. G. Cerutti gave his cooperation also in preparing the report.

The Istituto di Metrologia "G. Colonnetti" of the National Research Council of Italy developed, in cooperation with the Bureau International des Poids et Mesures (BIPM), Sèvres, a transportable absolute gravity meter, with 10 μ Gal uncertainty (*). This instrument has been used in the past five years to determine the gravity acceleration in 23 European sites to improve the International Gravity Standardization Net (IGSN 71) (**). Moreover, six absolute stations had been observed during a previous USA campaign in 1977 (***)

In Summer 1980 measurements were carried out in six sites in the United States: Boulder, Colorado; Alamogordo, New Mexico; Mc Donald Obs., Texas; Sheridan, Wyoming; Great Falls, Montana; Anchorage, Alaska.

The work was supported by the US Air Force Geophysical Laboratory, Hanscom AFB, Mass., under grant n° AFOSR-80-0157.

(*) Cerutti, G., Cannizzo, L., Sakuma, A., & Hostache, J. A transportable apparatus for absolute gravity measurements. VDI-Berichte n. 212, 1974: p. 49.

(**) Cannizzo, L., Cerutti, G., & Marson, I. Absolute gravity measurements in Europe. Il Nuovo Cimento, vol. 1C (n. 1), 1978: p. 39.

Marson, I., & Alasia, F. Absolute gravity measurements in Switzerland. P.I, IMGC Technical Report R 127, 1978. P. II, IMGC Technical Report R 142, 1979. P. III, IMGC Technical Report R 156, 1980.

(***) Marson, I., & Alasia, F. Absolute gravity measurements in the United States of America. Report AFGL-TR-78-0126.

Symbols and Abbreviations

g	value of gravity acceleration (*)
g_{corr}	value of g corrected for tide effect
g_f	final mean value of gravity acceleration at height h from pillar surface, normalized at a reference fringe number and corrected for electronic delay
g_r	gravity value reduced to reference level (floor or pillar surface) (**)
h	height from ground or pillar surface of the point where g is determined
m	standard deviation
M	standard error
N	number of interference fringes in the trajectory of projected body
N_m	total number of g measurements at each station
N_r	number of reference fringes
t	time interval between the two passages across the higher station during one trajectory
T	time interval between the two passages across the lower station during one trajectory
T.C.	Earth tides correction
U.Time	Greenwich mean time (Universal Time)
N.V.T. REJ.	Non vertical trajectory. Rejected

(*) The value of g is given by the formula

$$g = \frac{4 \cdot \lambda \cdot (N - 0.25)}{T^2 - t^2}$$

where $\lambda = 0.632\,991\,4122 \text{ }\mu\text{m}$ is the wavelength of the He-Ne laser beam.

(**) According to the resolution of the WG 2 of the International Gravity Commission, the Honkasalo term has not been included.

1. THE IMGC ABSOLUTE GRAVITY METER

1.1. Measurement method

The method adopted consists of the observation of the symmetrical free fall of a body in the gravitational field of the earth.

The advantages of this method are well known: relative freedom from residual air resistance and higher accuracy in time measurements, owing to the symmetry of the motion.

An object is projected vertically upwards and, in its rise and fall, it crosses twice two stations separated by distance L , whose value is accurately determined.

Two time intervals, T and t , corresponding to the two passages across the lower and upper stations respectively, are measured. The value of the acceleration due to the gravity force of the earth is given by

$$g = 8L/(T^2 - t^2) \quad (1)$$

The vertical gradient of the gravity force being assumed as constant along the whole trajectory, the value of g obtained from (1) corresponds to a point situated at height

$$z = L/6 + 1/3 \approx H/6 \quad (2)$$

from the apex of the trajectory downwards (l is the distance between the apex and the upper station and is negligible with respect to L).

The repeatability of the trajectory at each station and the determination of the apex are obtained with an uncertainty lower than 1 mm.

1.2. Technical description

The essential parts of the apparatus are a Michelson interferometer and a long-period seismometer (~ 20 s) (Figure 1). On the inertial mass of the seismometer is placed a corner cube (cc1) forming one mirror of the interferometer and the reference fixed point. The radiation from a stabilized HeNe laser is used. A second corner cube (cc2) is projected vertically in a vacuum cylinder (~ 0.1 Pa) and forms the movable mirror of the interferometer. Two

photodetectors (Ph a, Ph b) detect the interference fringes during the vertical motion of the corner cube and drive the electronic counters of the flight time and the trajectory length.

1.3. Measurement techniques

No physical standard of length is used, therefore measurements start at a pre-determined but arbitrary instant on the upward trajectory. At that point, fringe counting begins by means of a bi-directional counter guided by the signals of two photomultipliers. Simultaneously, computation of the total flight time begins as well. Another time counter is reset by each fringe in the rise and is stopped only by the first fringe in the fall motion, owing to phase relation inversion of the photodetector signals at the apex of the trajectory. This time interval is quantity "t" in eq. (1).

The upper station is therefore placed at the last fringe in the upward motion. If N is the total number of fringes recorded in the upward motion and λ the wavelength of the laser radiation, then

$$L = N \frac{\lambda}{2} \quad (3)$$

In the downward motion the counter counts the number of fringes in decreasing order, and when it reaches fringe 0, it stops counting of time T.

1.4. Errors

a) Distance measurement

It is directly connected with the measurement of the value of the laser light wavelength and with its stability. A maximum relative error of 5×10^{-9} , corresponding to $\pm 5 \mu\text{Gal}$, is expected.

Therefore, the laser wavelength is measured before and after each measurement trip.

Microseisms influence the determination of distance, as they alter the position of the fixed mirror.

These effects have been reduced by ~ 20 times by placing the fixed corner

cube on the inertial mass of the seismometer.

The mechanical shocks of the catapult on the movable corner cube can be a source of disturbance for the experiment; for this reason, measurements begin with a pre-determined delay with respect to the STARTING POINT in order to avoid vibration of the corner cube.

b) Laser beam verticality

Verticality is obtained using a mercury pool. The error must be less than 10^{-4} rad in order that errors in "g" measurements can be less than 5 μ Gal. No correction was applied to the g value for this error, but a ± 5 μ Gal uncertainty was introduced in the overall evaluation of measurement uncertainty.

c) Trajectory verticality

Deviation from verticality must be less than 10^{-4} rad over the whole trajectory, to obtain homogeneous visibility (> 80%).

d) Movable corner cube rotation

Rotations must be less than 0.03 rad/s. The corner cube must be adjusted so that the optical and gravity centres coincide within 0.1 mm.

e) Time determination

A rubidium time standard is used, with 10^{-10} stability approximately. A Hewlett-Packard counter, with ± 1 ns resolution is used to determine time T. The "start" and "stop" pulses, obtained from the fringe counter, are affected by the delay-time of the circuits used, which introduce a systematic error of 5 ns \pm 0.5 ns in the determination of T.

In total, the uncertainty in T measurements is of ± 1.5 ns corresponding to approximately ± 6 μ Gal in g determination (indicated as uncertainty of d.t.c. in the tables).

The error in the determination of t is much higher, owing to the fact that a counter with ± 100 ns resolution is used.

Yet, being

$$t \ll T$$

the error on t becomes negligible.

f) Other influence factors

The presence of magnetic fields induces electrical currents in the metal of the corner cube during flight. To avoid this effect, all the metallic parts are made of amagnetic material.

The elastic of the catapult may have an electrostatic charge, and the movable corner cube may be charged by residual air. The elastic is therefore protected by a grounded metallic tube.

Moreover, if the trajectory is vertical, the tube is perfectly centred with respect to the corner cube, so that the capacitance between them keeps constant during flight and its effect is negligible.

No corrections were made for buoyancy or for reduction of the wavelength of the laser light caused by residual air.

g) The measured g value corresponds to a height of ~ 0.8 m from the ground. To reduce it to this level, the vertical gradient of g has to be measured, and a correction applied. Two relative gravity meters, La Coste Romberg G-131 and La Coste Romberg D-26 (for Anchorage), have been used.

The results obtained at the individual stations, together with their measurement uncertainties, are given below. Δh represents the difference in the heights at which the Δg gravity difference was measured.

Vertical gradient of g at the different stations

Site	Δh (m)	Δg (μ Gal)	$\Delta g / \Delta h$ (μ Gal/m)
Boulder	$.780 \pm .001$	181 ± 3	232 ± 3
Alamogordo	$.780 \pm .001$	245 ± 2	314 ± 2
Mc Donald	$.780 \pm .001$	317 ± 2	407 ± 2
Sheridan	$.780 \pm .001$	200 ± 2	256 ± 2
Great Falls	$.780 \pm .001$	242 ± 2	310 ± 2
Anchorage	$.780 \pm .001$	206 ± 2	264 ± 2

A typical example of the evaluation of errors is given below, as well as their overall evaluation.

Source of error	Estimated uncertainty (μ Gal)
1) Laser wavelength	± 5
2) Beam direction	± 5
3) Time interval T (± 1.5 ns)	± 6
4) Gradient of g	± 2

The uncertainty in the g value is thus ± 10 μ Gal, calculated as the square root of the sum of the squares of the individual errors.

2. PREVIOUS MEASUREMENTS

As was said before, 23 European sites and six in the U.S. had been determined (Figure 2).

As relevant information, the agreement of the Italian apparatus with Sakuma's gravity meter and its repeatability are given in Tables A and B.

TABLE A Comparison with Sakuma's value of "g" at Sèvres

Station, date	g_r (μ Gal)	m (μ Gal)	M (μ Gal)
Sèvres A ₃ by Sakuma	980 925 900		
Sèvres, May 1976	980 925 892	20	2.0
Sèvres, June 1976	980 925 902	17	1.8
Sèvres, January 1977	980 925 896	19	2.1
Sèvres, March 1977	980 925 906	17	1.9

TABLE B Repeatability of the measurements in the same station

Station, date	g_r (μ Gal)	m (μ Gal)	M (μ Gal)
Sèvres, May 1976	980 925 892	20	2.0
Sèvres, June 1976	980 925 902	17	1.8
Sèvres, January 1977	980 925 896	19	2.1
Sèvres, March 1977	980 925 906	17	1.9
Gävle, July 1976	981 923 527	19	1.6
Gävle, August 1976	981 923 533	17	1.9
Gävle, September 1976	981 923 524	20	3.1
Torino, July 1976	980 534 256	26	3.1
Torino, October 1976	980 534 251	25	4.1
Torino, June 1977	980 534 259	25	2.6
Torino, September 1977	980 534 259	30	3.3.
Bedford, Mass, Oct1977	980 378 671	24	2.4
Bedford, Mass, Dec 1977	980 378 675	29	3.6

3. U.S. MEASUREMENTS

From May 26 to June 29, 1980 the IMGC apparatus was used in the United States. The basic criteria for site selection were the establishment of a high-precision calibration line running from Mc Donald Obs. (Texas) to Greer Falls (Montana). Studies concerning monitoring of gravity field variations in a seismic area suggested the observation of the site in Anchorage (Alaska).

The following stations were therefore selected:

Mc Donal Obs., Texas

Alamogordo, New Mexico

Boulder, Colorado

Sheridan, Wyoming

Great Falls, Montana

Anchorage, Alaska

which are described in the Appendix.

Some comments are necessary about measurements in Alamogordo, N M, a site already observed in 1977 with the IMGC apparatus and subsequently with Hammond's.

Results indicated significant discrepancy between the two instruments (80 „Gal). Measurements carried out with both instruments in other sites (Bedford, Denver) did not show the presence of systematic effects that could account for this high discrepancy. Therefore simultaneous measurements with both instruments were organized in Alamogordo in 1980, to explain this ambiguous behaviour.

The measurements in question were carried out in three days. The results obtained by the IMGC instrument on May 31, 1980 are quite different from those of June 2 and 3. In fact, the results of May 31 are in very satisfactory agreement with those of 1977, whereas the results of June 2 and 3 indicate better agreement with Hammond's instrument. In an attempt to find an environmental condition that could have affected the 1977 measurements and those of May 31, 1980, it was found out that in both periods a system for gyroscope testing was operating at a few metres' distance, and that it was switched off on June 2 and 3. As the system was of a classified character, it was not possible to have the information necessary for thorough understanding of the interaction between the system and the gravity meter.

The gyroscope testing system was turned on again on June 3 in the afternoon, and once more results showed the mentioned discrepancy. Table C summarizes the results of the various measurements.

A synopsis of the results of the measurements carried out in the United States are reported in Tables C and D.

TABLE C
ALAMOGORDO MEASUREMENTS

Date	g Reduced (μGal)	Error (μGal)	Note
Nov. 3-7 1977	979 139 513	11	Gyro. Test. Syst. on
May 31 1980	979 139 516	11	" " " "
June 3 1980	979 139 519	15	" " " "
June 2-3 1980	979 139 514	12	" " " off

TABLE D
Synopsis of U.S. Measurements

Site	Date	g Reduced (μGal)	Error (μGal)
Boulder, CO	May 26-27, 1980	979 608 498	11
Alamogordo, NM	June 2-3, 1980	979 139 584	12
Mc Donald Obs, TX	June 6-7, 1980	978 820 097	11
Sheridan, WY	June 12-14, 1980	980 209 007	11
Great Falls, MO	June 17-18, 1980	980 497 412	10
Anchorage, AL	June 27-28, 1980	981 928 998	10

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- prof. A. Bray and dr. G. Cerutti for the logistic organization in Italy.
- prof. J. Faller and his staff for their most helpful assistance in repairing the instrument damaged in transport.
- Mr. L. Cannizzo for his assistance in repairing the instrument.
- Mr. W. Spita for his valuable assistance during field operations.

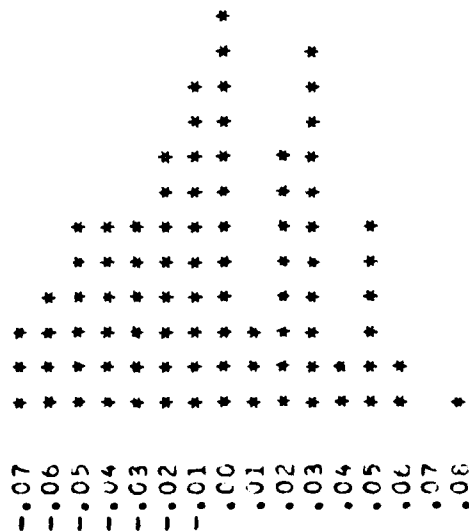
BOULDER, COLORADO

MAY 26-27 1980

STATISTICS

TOTAL MEAS. 98
 MEAS. USED 90
 MEAS. REJECTED 8
 MEAN 979608.333
 STANDARD DEVIATION .038
 STANDARD ERROR .004

HISTOGRAM INTERVAL = .01 MILLIGAL



REDUCTION AT THE FLOOR

SOURCE	VALUE	ERROR
HEIGHT	.799	.001
GRADIENT	.235	.002
GRAVITY VAL.	979608.333	.004
DELTA G	.188	.002
D.T.C.	-.023	.007
G REDUCED	979608.498	.011

ALAMOGORDO, NEW MEXICO MAY 31 1966 0430. EAST. SWIFT. 14

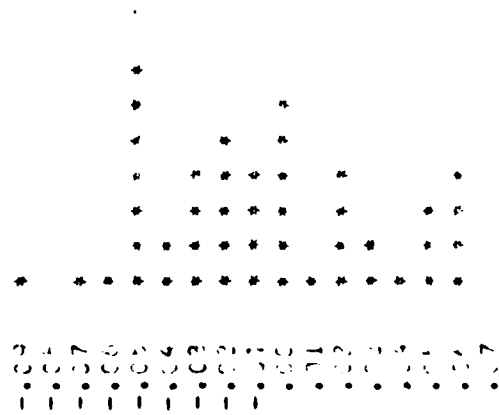
STATISTICS

TOTAL MEAS. 48
 MEAS. USED 48
 MEAS. REJECTED 0
 MEAN 974139.247
 STANDARD DEVIATION .003
 STANDARD ERROR .006

REDUCTION AT THE FLOR

SOURCE	VALUE	STDEV
HEIGHT	.772	.002
GRAVITY	.324	.003
GRAVITY VAL.	975134.247	.002
DELTA	.242	.002
DELTA	.002	.004
DELTA	.002	.004
DELTA	.002	.004

HISTOGRAM INTERVAL = .01 MILLIGAL

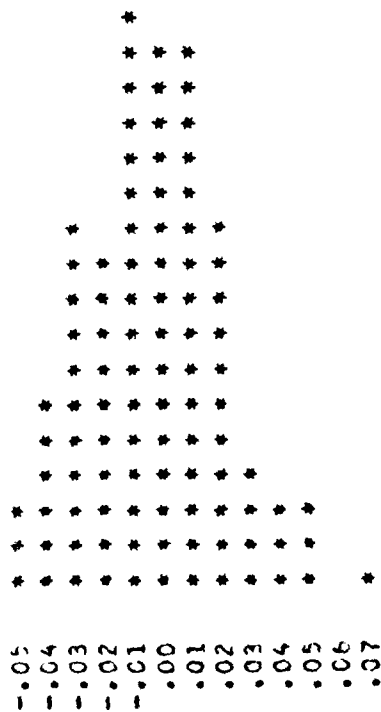


ALAMOGOGO, NEW MEXICO JUNE 2-3 1980

STATISTICS

TOTAL MEAS. 101
 MEAS. USED 101
 MEAS. REJECTED 0
 MEAN 979139.391
 STANDARD DEVIATION .024
 STANDARD ERROR .002

HISTOGRAM INTERVAL = .01 MILLIGAL



REDUCTION AT THE FLOOR

SOURCE	VALUE	ERROR
HEIGHT	.702	.001
GRADIENT	.314	.002
GRAVITY VAL.	979139.391	.002
DELTA G	.220	.002
D.T.C.	-.027	.009
G REDUCED	979139.584	.012

FLAMERSDORF JUNE 3 1960 GYRC. TEST. SYST. ON

STATISTICS

TOTAL MEAS. 12
 MEAS. USED 12
 MEAS. REJECTED 0
 MEAN 979139.326
 STANDARD DEVIATION .022
 STANDARD ERROR .010

HISTOGRAM INTERVAL = .01 MILLIGAL

-.10 *
 -.09 *
 -.08 *
 -.07 *
 -.06 *
 -.05 *
 -.04 *
 -.03 *
 -.02 *
 -.01 *
 .00 *
 .01 *
 .02 *
 .03 *
 .04 *
 .05 *
 .06 *

REDUCTION AT THE FLOOR

SOURCE	VALUE	ERROR
HEIGHT	.702	.001
GRADIENT	.314	.002
GRAVITY VAL.	979139.326	.010
DELTA G	.220	.002
J.T.C.	-.027	.003
G REDUCED	979139.519	.015

MC DONALD JRS., TEXAS JUNE 6-7 1980

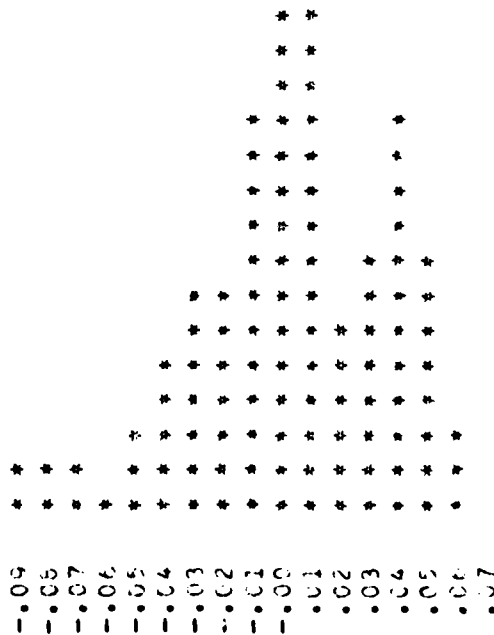
STATISTICS

TOTAL MEAS. 115
 MEAS. USED 109
 MEAS. REJECTED 6
 MEAN 97819.430
 STANDARD DEVIATION .035
 STANDARD ERROR .003

REDUCTION AT THE FLOOR

SOURCE	VALUE	ERROR
HEIGHT	.717	.301
GRAFICIENT	.407	.002
GRAVITY VAL.	97819.430	.003
DELTA G	.292	.002
D.T.C.	-.025	.003
G REDUCED	97820.097	.011

HISTOGRAM INTERVAL = .01 MILLIGAL



CHERIDAN, MONTING JUNE 12-13 1960

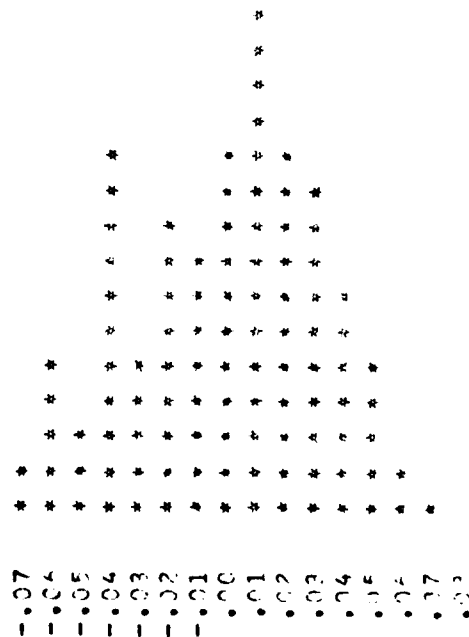
STATISTICS

TOTAL MEAS. 121
 MEAS. USED 105
 MEAS. REJECTED 16
 MEAN 330200.867
 STANDARD DEVIATION .333
 STANDARD ERROR .003

REDUCTION AT THE SIGN

SOURCE	VALUE	PERCENT
HEIGHT	.458	.001
GRADIENT	.254	.002
GRAVITY VAL.	000200.867	.003
DELTA G	.168	.002
DELTA G	-.022	.002
G REDUCED	000200.007	.011

HISTOGRAM INTERVAL = .01 MILLICAL



GREAT FALLS, MONTANA JUNE 17-18 1980

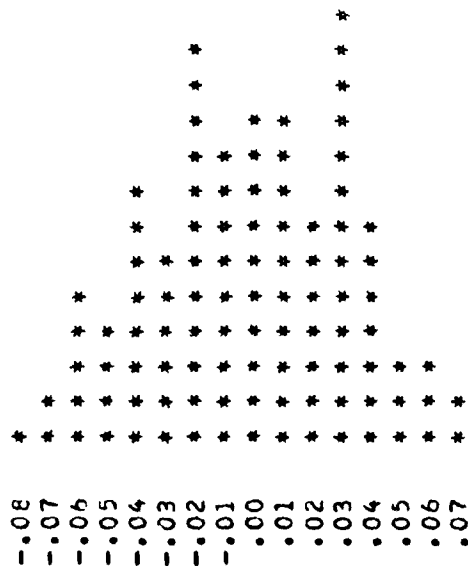
STATISTICS

TOTAL MEAS. 112
 MEAS. USED 103
 MEAS. REJECTED 9
 MEAN 980497.219
 STANDARD DEVIATION .036
 STANDARD ERROR .004

REDUCTION AT THE FLOOR

SOURCE	VALUE	ERROR
HEIGHT	.705	.001
GRACIENT	.310	.002
GRAVITY VAL.	980497.219	.004
DELTA G	.219	.002
D.T.C.	-.026	.001
G REDUCED	980497.412	.010

HISTOGRAM INTERVAL = .01 MILLIGAL



ANCHORAGE, ALASKA JUNE 27-28 1980

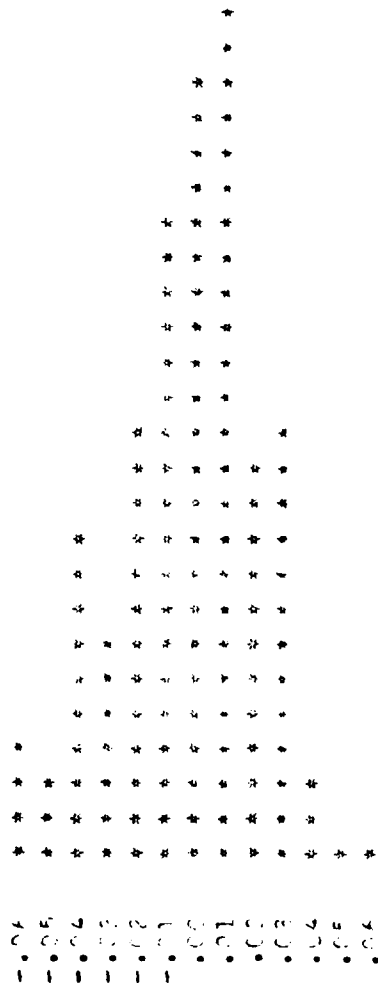
STATISTICS

TOTAL MEAS. 126
 MEAS. USED 124
 MEAS. REJECTED 2
 MEAN 2-1320.837
 STANDARD DEVIATION .028
 STANDARD ERROR .002

REDUCTION AT THE FLOOD

SOURCE	VALUE	ERROR
RETAIN	.706	.001
GRADIENT	.264	.002
GRAVITY VAL.	981928.827	.002
DELTA C	.186	.002
D.T.C.	-.028	.007
C. ADJUSTED	981528.658	.010

HISTOGRAM INTERVAL = .01 MILLICAL



BOULDER, CO MAY 26 1980

W.T. HR.	N. FRINGES	TOT. TIME MICRO S	TIME APEX MICRO S	T.C. MILLIGAL	G. VALUE MILLIGAL	NOTE
15.30	691234	422593.488	309.5	.0627	979608.2625	N.V.T. REJ.
15.34	686798	421325.165	469.6	.0647	979608.2684	N.V.T. REJ.
15.37	675493	417842.965	222.2	.0622	979608.3147	
15.40	673492	417223.706	344.7	.0677	979608.3158	
15.43	675804	417939.340	445.8	.0698	979608.2333	N.V.T. REJ.
16.01	638611	421880.710	216.9	.0772	979608.2187	N.V.T. REJ.
16.03	683412	420285.259	459.4	.0781	979608.2329	N.V.T. REJ.
16.07	676613	418189.253	243.4	.0796	979608.2491	N.V.T. REJ.
16.10	676097	418029.961	480.6	.0808	979608.2822	N.V.T. REJ.
16.12	675879	417962.545	475.4	.0815	979608.3303	
16.14	673355	417181.197	252.3	.0823	979608.3560	
16.16	676107	418032.957	399.2	.0830	979608.3304	
16.18	673392	417192.717	309.7	.0837	979608.2648	
16.20	671072	416473.512	496.9	.0843	979608.2697	
16.25	673573	417248.700	176.0	.0859	979608.2844	
17.10	665255	414664.595	452.4	.0953	979608.2655	
17.17	669264	415912.177	479.8	.0958	979608.3104	
17.21	665050	414503.737	375.6	.0959	979608.2827	

BOULDER, CO MAY 26 1980

U.M.T. HR. MIN	N. FRINGES	TGT. TIME MICRO S	TIME APEX MICRO S	T.C. MILLIGAL	G. VALUE MILLIGAL	NOTE
13.54	558436	412533.799	341.0	.0784	979608.3344	
13.58	579577	419104.376	439.9	.0768	979608.2705	
14.05	579051	418941.931	194.8	.0737	979608.4188	
14.07	572985	417066.554	233.8	.0728	979608.3399	
14.10	553331	414064.450	406.3	.0715	979608.3968	
14.12	657781	415450.991	364.9	.0707	979608.3374	
14.15	664277	414359.626	438.0	.0693	979608.4275	
14.18	664647	414474.909	293.2	.0668	979608.2973	
14.21	563658	416034.473	384.0	.0663	979608.3351	
14.24	669431	415964.018	437.4	.0649	979608.2786	
14.27	675160	417740.087	388.5	.0639	979608.2890	
14.28	564509	414431.893	324.9	.0629	979608.3288	
14.30	661651	413539.741	358.2	.0619	979608.3287	
14.32	664670	414482.120	346.4	.0607	979608.2911	
14.38	655193	411516.524	230.5	.0575	979608.3924	
14.40	666875	415169.068	362.2	.0564	979608.3100	
14.44	659353	412824.225	477.2	.0542	979608.3394	

BOULDER, CO MAY 26 1980

G.M.T. HR. MIN	N. FRINGES	TOT. TIME MICRO S	TIME APEX MICRO S	T.C. MILLIGAL	G. VALUE MILLIGAL	NOTE
20.12	679731	419151.841	425.7	.0362	979608.2512	N.V.T. REJ.
20.13	668121	415556.794	435.0	.0360	979608.3696	
20.17	657300	412177.616	51.2	.0347	979608.3820	
20.19	661072	413358.729	352.2	.0334	979608.4252	
20.20	664530	414438.342	191.1	.0329	979608.3751	
20.22	658827	412656.182	242.4	.0316	979608.3677	
20.24	656793	412018.854	425.4	.0303	979608.3051	
20.26	650638	410083.585	261.4	.0291	979608.3653	
20.26	650601	410071.879	176.6	.0278	979608.3658	
20.31	653533	410994.946	314.7	.0260	979608.3281	
20.35	547648	409140.155	94.0	.0234	979608.3831	
20.37	654254	411221.729	486.6	.0218	979608.4349	N.V.T. REJ.
20.40	655060	411474.983	496.5	.0203	979608.3850	
20.42	661452	413477.675	489.0	.0190	979608.3174	
20.44	656313	411868.095	227.2	.0161	979608.3734	
20.45	653390	412919.372	336.6	.0171	979608.3340	
20.47	555743	411689.413	472.6	.0158	979608.3733	
20.49	656586	411953.913	433.5	.0146	979608.3646	
20.50	554842	411419.070	483.9	.0139	979608.3263	
20.52	628763	412636.160	279.5	.0127	979608.3572	
20.54	660523	413187.060	337.5	.0114	979608.3097	
20.56	654678	411354.920	433.5	.0108	979608.3662	
20.57	654641	415730.783	281.8	.0095	979608.3255	

BOULDER, CO MAY 26 1960

S.M.T. HR. MIN	N. FRINGES	TOT. TIME MICRO S	TIME APEX MICRO S	T.C. MILLIGAL	G. VALUE MILLIGAL	NOTE
22.31	673330	417173.582	426.2	-0.0432	979608.2864	
22.33	664553	414445.605	330.2	-0.0440	979608.2816	
22.35	660798	413273.145	440.2	-0.0440	979608.3260	
22.36	659300	412804.211	90.8	-0.0453	979608.3619	
22.38	662103	413680.988	414.7	-0.0462	979608.3831	
22.39	654190	414332.313	197.7	-0.0466	979608.2812	
22.41	653638	411043.765	419.0	-0.0474	979608.3001	
22.43	654030	411151.063	63.4	-0.0483	979608.3244	
22.45	650525	410047.965	252.1	-0.0491	979608.2960	
22.47	655293	411546.158	505.2	-0.0498	979608.3544	
22.49	650504	410041.386	322.1	-0.0506	979608.3396	
22.51	658586	412580.819	396.1	-0.0528	979608.2827	
22.53	603214	414027.928	408.3	-0.0539	979608.2974	

BOULDER, CO MAY 27 1980

G.M.T. HR. MIN	N. FRINGES	TOT. TIME MICRO S	TIME APEX MICRO S	T.C. MILLIGAL	G. VALUE MILLIGAL	NOTE
16.30	690738	422531.965	479.3	.0930	979608.3137	
16.32	684031	420475.450	340.5	.0938	979608.3383	
16.34	685928	421057.983	112.3	.0947	979608.2722	
16.36	675102	417722.220	460.9	.0955	979608.3071	
16.40	671761	416687.320	472.4	.0972	979608.3220	
16.44	679013	418621.858	469.3	.0989	979608.3040	
16.46	675960	417987.509	404.0	.0997	979608.3731	
16.47	675098	417720.981	459.3	.1000	979608.3104	
16.49	675972	417991.148	318.4	.1008	979608.3610	
16.51	674918	417665.106	264.5	.1015	979608.3799	
16.53	664690	414488.379	385.8	.1022	979608.3878	
16.55	676720	418222.431	392.7	.1029	979608.2751	
16.57	672135	416818.839	497.9	.1036	979608.2886	
16.59	664447	414412.664	432.1	.1043	979608.3362	
17.00	672743	416991.563	214.4	.1046	979608.3103	
17.03	670185	416198.145	381.2	.1054	979608.3565	
17.06	666253	414975.477	435.1	.1062	979608.3602	
17.07	664244	414349.311	396.0	.1065	979608.3717	
17.09	653461	414104.844	46.7	.1070	979608.3452	
17.10	661844	413600.055	364.9	.1073	979608.3792	
17.13	664917	414559.192	412.8	.1082	979608.3154	
17.32	667340	415313.876	449.2	.1118	979608.3498	
17.55	678240	418691.849	388.6	.1134	979608.3096	
17.57	674051	417396.822	342.0	.1134	979608.3340	
18.01	673449	417210.375	322.8	.1135	979608.3342	
18.05	674617	417572.000	317.0	.1132	979608.3775	
18.07	677221	418377.300	487.4	.1131	979608.3527	

SLANCOGGER 03,MM MAY 31 1980 CYC. TEST. SYS. IN

W.M.I. HR.MIN	N. FRINGES	TOT. TIME MICRO S	TIME APPEX MICRO S	F.C. MILLIGAL	C. VALUE MILLIGAL
15.10	774967	447631.109	310.3	-0.593	979139.3427
15.12	772075	445823.892	292.0	-0.340	979139.3056
15.15	773452	447369.595	256.5	-0.360	979139.3473
15.20	753233	445739.460	379.2	-0.323	979139.3522
15.24	770518	446460.039	251.1	-0.294	979139.2761
15.26	767195	445409.753	470.7	-0.279	979139.2492
15.28	759237	446001.989	319.8	-0.265	979139.2409
15.30	759155	442780.522	198.4	-0.140	979139.2524
16.05	780224	449175.942	457.2	-0.147	979139.2103
16.17	763423	446055.942	419.1	0.104	979139.2385
16.09	779709	446426.543	464.0	0.121	979139.2742
15.11	769742	445858.306	179.9	0.138	979139.2424
15.16	752322	444865.544	250.6	0.182	979139.2754

ALUMINUM DYE MAY 31 1950 CAPT. TEST. SYST. ON

Q.W.T. H.M.P.N	N. FRAMES	TOT. TIME MICRO S	TIME AREA MICRO S	T.C. MILLICAL	S. VALUE MILLICAL	NOTE
17.05	771557	445702.162	440.4	.0654	979139.2593	
17.06	771610	446685.374	301.6	.0604	979139.3351	
17.10	769654	446126.430	444.8	.0623	979139.3420	
17.11	773522	447242.522	470.5	.0633	979139.3130	
4.71	772503	446947.885	420.4	.0651	979139.3403	
17.15	759729	446128.720	172.0	.0670	979139.3249	
17.16	757937	445625.113	480.1	.0679	979139.3241	
17.17	770926	446491.367	311.3	.0606	979139.2744	
17.20	757773	445577.313	201.1	.0731	979139.3024	
17.22	757920	445020.062	354.0	.0731	979139.3030	
17.25	764975	444764.676	204.2	.0756	979139.2491	
17.27	759754	443247.453	495.0	.0774	979139.2465	

ALAMCOURD, JM MAY 24 1960 GPER. TEST. SYST. ON

G.P.I. M.P.M	N. SPINGS	TOT. TIME MICRO S	TIME APPEX MICRO S	I.C. MILLIGAL	% VALUE MILLIGAL	NOTE
19.07	755821	450804.069	157.7	.1448	579134.2749	
19.09	777876	446494.365	97.9	.1456	579139.2509	
19.10	775102	447957.191	472.3	.1450	579129.2721	
19.12	772031	446825.667	215.4	.1468	579135.2339	
19.15	775351	448059.523	345.0	.1480	579139.3197	
19.16	757755	445574.983	125.4	.1483	579134.2955	
19.15	770972	446504.843	485.4	.1490	579134.3580	
19.21	775021	447693.029	413.2	.1500	579134.2897	
19.24	765375	445171.551	312.0	.1510	579135.2762	

ALAMOGORDO, NM MAY 31 1980 CYPR. TEST. SVST. 00

6.0.1. 42.12	N. FRINGES	TOT. TIME MICRO S	TIME AP-EX MICRO S	I.O. MILLIGAL	C. VALUE MILLIGAL	W.T.
19.41	771213	446574.915	333.7	.1544	979139.2314	
19.42	771127	446549.722	482.1	.1573	979139.3557	
19.57	757904	445632.875	393.2	.1576	979139.3257	
20.00	753305	444279.402	361.0	.1580	979139.3471	
20.01	770712	445425.463	377.5	.1581	979139.2770	
20.03	754343	444580.374	287.1	.1582	979139.2451	
20.08	754731	445855.315	323.7	.1584	979139.2582	
20.10	755710	444978.492	458.5	.1587	979139.2905	
20.12	765778	444990.190	398.0	.1588	979139.2480	
20.14	754345	444581.747	409.3	.1589	979139.2463	
20.16	767142	445346.098	426.5	.1591	979139.2197	
20.20	770749	446454.694	422.3	.1597	979139.3046	
20.22	757731	445575.348	441.5	.1571	979139.2943	
20.24	755245	445133.940	490.1	.1572	979139.2432	

ALAMOGORDO, NM JUNE 2 1980

G.M.T. HR. MIN	N. FRINGES	TOT. TIME MICRO S	TIME APEX MICRO S	T.C. MILLIGAL	G. VALUE MILLIGAL	NOTE
19.50	582418	382082.496	244.5	.0997	979139.3815	
19.51	571454	384415.813	400.2	.1002	979139.3915	
19.53	577450	386424.031	493.1	.1012	979139.3532	
19.55	579823	387217.222	506.6	.1023	979139.3842	
19.56	570745	384173.740	176.9	.1029	979139.3877	
19.57	573364	385054.303	370.4	.1043	979139.4014	
19.57	573364	385054.303	370.4	.1034	979139.4005	
19.58	569567	383777.270	425.8	.1039	979139.3847	
19.59	575244	385685.195	489.5	.1045	979139.4018	
20.00	573487	385095.756	501.8	.1050	979139.3775	
20.01	570034	383934.434	272.7	.1135	979139.3837	
20.03	566904	382878.311	80.4	.1146	979139.4388	
20.04	568310	383353.355	186.5	.1151	979139.4147	
20.06	572217	384668.876	261.9	.1162	979139.4111	
20.07	557210	382982.453	496.7	.1167	979139.3987	
20.08	574858	385555.622	347.9	.1172	979139.3967	
20.11	574697	385498.275	348.1	.1189	979139.3900	
20.13	567718	383153.736	316.0	.1199	979139.3436	
20.15	575891	385598.508	309.1	.1210	979139.3495	
20.20	563229	383326.190	391.0	.1220	979139.4155	
20.22	576614	386143.866	61.7	.1226	979139.4380	
20.24	575702	385938.555	346.2	.1236	979139.3816	
20.25	573350	385049.466	154.1	.1240	979139.3635	
20.26	575579	385797.503	498.0	.1244	979139.3736	
20.27	573042	384946.179	377.7	.1248	979139.3870	
20.29	557947	383231.199	508.1	.1256	979139.4104	
20.30	579236	387020.952	292.9	.1260	979139.3616	

ALAMJGGRDQ ,NM JUNE 2 1980

G.M.T. HR. MIN	N. FRINGES	TOT. TIME MICRO S	TIME APEX MICRO S	T.C. MILLIGAL	G. VALUE MILLIGAL	NOTE
20.31	573153	384983.295	125.7	.1263	979139.3887	
20.35	573216	385004.566	313.2	.1268	979139.3569	
20.34	563547	383433.581	505.4	.1271	979139.3632	
20.35	567926	383223.949	357.3	.1273	979139.3846	
20.35	572512	384768.091	342.9	.1276	979139.3804	
20.37	570298	384023.567	507.1	.1279	979139.4007	
20.39	570153	383974.486	231.9	.1274	979139.3673	
20.40	574097	365300.364	375.7	.1287	979139.4053	
20.42	570096	383955.457	428.7	.1292	979139.3908	
20.43	567976	383240.829	371.6	.1295	979139.4005	
20.44	566656	382795.375	496.4	.1297	979139.4150	
20.45	566584	382771.015	459.9	.1300	979139.3869	
20.47	570652	384142.675	457.1	.1305	979139.3917	
20.48	567553	383097.933	121.9	.1308	979139.3987	
20.49	561505	381051.380	315.7	.1311	979139.3905	
20.51	567433	383057.730	488.4	.1316	979139.3629	
20.52	570031	383933.652	503.7	.1319	979139.4290	
20.53	571006	384261.805	455.0	.1321	979139.3884	
20.55	573420	385072.935	47.2	.1327	979139.4108	
20.56	564516	382071.763	403.1	.1329	979139.4080	
20.57	565632	382449.328	479.1	.1332	979139.3959	
20.58	569503	383418.671	453.4	.1335	979139.4089	
21.00	566577	382768.658	464.4	.1340	979139.3802	
21.01	569340	383700.771	409.7	.1341	979139.3997	
21.02	570072	383954.005	313.0	.1342	979139.3614	
21.03	568511	383421.441	506.7	.1344	979139.3815	
21.04	569942	383916.917	263.5	.1345	979139.3966	
21.06	569235	383665.336	357.1	.1348	979139.3851	

ALAMJGGRD, NM JUNE 2 1980

G.M.T. HF. MIN	N. FRINGES	TOT. TIME MICRO S	TIME APEX MICRO S	T.C. MILLIGAL	G. VALUE MILLIGAL	NOTE
21.30	581300	387709.949	374.9	.1370	979139.3877	
21.31	574829	385545.997	437.2	.1370	979139.3693	
21.32	579020	386614.704	495.6	.1370	979139.4002	
21.34	574020	386614.704	495.6	.1370	979139.4002	
21.34	573359	386728.074	503.1	.1370	979139.3737	
21.35	579753	367193.774	441.8	.1370	979139.3999	
21.30	573984	386936.304	348.5	.1370	979139.3778	
21.37	574612	386812.442	319.4	.1370	979139.4415	
21.38	573611	385137.199	318.7	.1370	979139.3717	
21.39	573121	384972.681	348.3	.1340	979139.4157	
21.40	574449	385418.307	121.2	.1370	979139.3917	
21.42	573824	387240.811	407.9	.1370	979139.4255	
21.43	575559	386125.569	255.7	.1370	979139.3521	
21.44	530523	387450.656	262.1	.1370	979139.3661	
21.46	574071	385291.799	513.1	.1369	979139.4061	
21.47	573451	387036.186	376.9	.1367	979139.3978	
21.48	573202	384999.847	298.8	.1366	979139.3969	
21.49	575332	386049.750	470.2	.1365	979139.3589	
21.51	580730	387519.695	211.8	.1362	979139.3738	
21.52	575544	386134.012	357.9	.1361	979139.3991	
21.53	573227	385109.023	359.3	.1359	979139.4257	
21.54	577734	386518.846	297.5	.1358	979139.3686	
21.55	587127	389648.432	472.1	.1356	979139.3597	
21.55	584519	388782.001	413.3	.1355	979139.3528	

ALAMCGR00, NM JUNE 3 1980

G.M.T. HR. MIN	N. FRINGES	TOT. TIME MICRO S	TIME APEX MICRO S	T.C. MILLIGAL	G. VALUE MILLIGAL	NOTE
13.54	527013	369162.391	399.3	-.0592	979139.3692	
13.55	530598	370415.892	421.1	-.0595	979139.3990	
13.55	526352	368935.419	450.8	-.0597	979139.4004	
14.00	532049	370922.069	466.9	-.0600	979139.4597	
14.02	527924	369491.426	490.4	-.0601	979139.3981	
14.03	527678	369395.228	400.1	-.0602	979139.3686	
14.05	532954	371237.430	486.1	-.0303	979139.4478	
14.07	533587	371457.679	356.9	-.0605	979139.4267	
14.09	532934	371230.220	233.9	-.0606	979139.4160	
14.11	530227	370286.203	228.5	-.0609	979139.3874	
14.14	538362	373116.207	503.2	-.0609	979139.4316	
14.15	530736	370464.085	437.1	-.0610	979139.3550	
14.17	532041	370919.249	423.5	-.0611	979139.3438	
14.19	532740	371162.698	288.7	-.0613	979139.3432	
14.20	532516	371084.669	306.7	-.0613	979139.3658	
14.21	539150	373389.105	448.4	-.0614	979139.4148	
14.23	532547	371102.361	203.1	-.0615	979139.3979	
14.24	529150	369560.442	436.3	-.0616	979139.3627	
14.25	529203	369579.029	472.9	-.0617	979139.3641	
14.26	530300	370311.914	469.5	-.0617	979139.4140	
14.27	528462	369669.620	475.1	-.0618	979139.4203	
14.28	528309	369615.875	232.4	-.0619	979139.3972	

ALAN 303103 JUNE 3 1960 GYPS. TEST. SYST. ON

WAVELENGTH	WAVELENGTH	TIME APX	T.C.	S. VALUE	NOTE
microns	microns	microns	microns	microns	
1.0001	374060.444	123.0	.0023	374134.3329	
1.0007	374731.076	511.7	.0039	374129.3701	
1.0015	374734.387	425.7	.0080	374134.2257	
1.0017	374231.114	349.3	.0091	374129.2349	
1.0019	377506.165	189.2	.0101	374159.3322	
1.0020	375611.010	424.8	.0107	374136.2451	
1.0022	374269.595	415.4	.0117	374127.2331	
1.0024	374542.216	265.2	.0128	374129.3354	
1.0025	374317.974	319.1	.0133	374129.3250	
1.0027	374244.332	162.0	.0136	374134.2415	
1.0029	377539.732	472.4	.0144	374134.3372	
1.0031	374360.347	107.1	.0155	374129.3151	

NO. 1000-1000-1000 JUNE 4 1960

NO. 1000-1000-1000	NO. 1000-1000-1000	TIME APPEX MIGAL S	T.C. MILLIGAL	G. VALUE MILLIGAL	NOTE
12.40	372244.300	127.7	.0523	978819.7404	
13.40	371459.200	212.1	.0536	978819.7591	
13.50	373105.600	322.3	.0538	978819.8015	
13.52	371454.007	455.3	.0540	978819.8364	
13.56	371710.625	494.2	.0545	978819.7581	
14.00	372754.450	235.3	.0550	978819.7681	
14.02	375240.120	195.6	.0551	978819.7910	
14.04	369944.432	322.1	.0552	978819.7365	
14.06	372792.201	124.2	.0553	978819.8087	
14.07	375110.346	321.4	.0554	978819.8370	
14.10	373507.564	131.1	.0555	978819.8416	

MC DONALD BAS., TEXAS JUNE 6 1960

W.V.I. W.P. IN	N. BRIDGES	SET. TIME MICRO S	TIME APEX MICRO S	7.C. MILLIGAL	C. VALUE MILLIGAL	NOTE
14.50	550207	374311.534	500.5	.0345	478519.8034	
14.52	550385	377321.403	453.1	.0343	478519.8307	
14.53	543439	374339.361	387.3	.0341	478519.9301	N.V.I.
14.55	554133	378505.114	224.1	.0339	478519.8712	
14.57	545630	376031.795	510.1	.0337	478519.8408	
15.00	547872	375458.618	412.5	.0334	478519.8649	
15.04	540946	374071.419	311.5	.0328	478519.9056	N.V.I.
15.06	541959	374421.717	505.0	.0324	478519.9120	N.V.I.
15.08	545448	375624.845	413.4	.0321	478519.8553	
15.10	545442	375950.740	401.7	.0320	478519.8097	N.V.I.
15.11	540717	375745.239	252.0	.0316	478519.8354	
15.13	551408	377671.040	436.9	.0313	478519.8485	
15.14	551210	377009.537	245.2	.0311	478519.8760	
15.15	545550	375940.815	301.0	.0310	478519.8480	N.V.I.
15.17	553252	375302.329	326.8	.0306	478519.8568	
15.19	550376	377317.973	459.7	.0302	478519.8345	
15.20	542459	374507.555	337.0	.0300	478519.8663	
15.23	550001	377183.329	410.0	.0294	478519.9302	N.V.I.
15.22	543083	375246.265	263.2	.0294	478519.8522	
15.24	547335	376274.939	212.7	.0292	478519.8550	
15.26	552023	377405.490	390.2	.0291	478519.8502	
15.28	554414	378095.581	403.4	.0284	478519.8707	
15.32	550052	378212.239	412.1	.0285	478519.8445	
15.34	552452	374524.546	247.1	.0281	478519.8710	
15.35	545500	375303.150	338.2	.0268	478519.8229	
15.37	543056	375205.452	377.7	.0263	478519.8527	
15.38	551035	377544.203	202.7	.0258	478519.8573	

MC DONALD DME, TEXAS JUNE 6 1963

W. T. 48.410	N. FRINGS	INT. TIME MICRO S	TIME APPL MICRO S	T.C. MILLIGAL	S. VALUE MILLIGAL	NOTE
15.45	530054	370237.054	370.7	.0270	978819.8095	
15.42	554011	379426.161	509.5	.0252	978819.8522	
15.43	552732	378158.423	458.4	.0222	978819.8271	
15.47	553735	378447.408	321.0	.0245	978819.8676	
15.49	555306	379003.293	191.9	.0234	978819.8315	
15.50	556552	379429.034	406.7	.0234	978819.8382	
15.51	559454	380537.825	317.7	.0231	978819.8762	
15.52	559387	380394.256	471.7	.0227	978819.8353	
15.53	561604	381167.597	400.7	.0224	978819.8003	

MC DONALD RES. TEXAS JUN 5 1950

DATE TIME	N. BRIDGES	INT. TIME MICRONS	TIME APPLX MICRONS	I.C. MILLIGAL	C. VALUE MILLIGAL	NOTE
15.10	521577	334553.319	221.0	-0024	27819.0033	
15.11	523507	351742.311	247.5	-0039	27819.0254	
15.13	523965	340240.004	244.5	-0045	27819.0155	
15.16	525423	375385.050	415.0	-0056	27819.0314	
15.18	527347	380720.305	331.0	-0061	27819.0573	
15.19	527559	383152.504	195.5	-0054	27819.7893	
15.20	528979	383541.751	457.0	-0057	27819.8491	
15.21	553202	374265.254	255.5	-0069	27819.8591	
15.22	547404	377053.069	241.5	-0072	27819.8717	
15.24	549806	379515.064	460.5	-0074	27819.8815	
15.25	553445	361920.243	253.5	-0089	27819.8279	
15.30	554046	341973.741	345.4	-0084	27819.8760	
15.31	557503	374664.782	225.5	-0085	27819.8413	
15.33	554622	378740.619	121.0	-0103	27819.7028	
15.35	554314	352068.031	130.9	-0109	27819.7359	
15.37	553241	351478.426	334.0	-0114	27819.8141	
15.40	554401	345459.251	246.0	-0172	27819.8323	
15.42	552441	341542.523	307.2	-0125	27819.8010	
15.44	553931	340223.150	445.5	-0126	27819.8105	
15.45	553641	330140.047	491.4	-0130	27819.8123	
15.47	554723	374405.154	400.7	-0136	27819.7924	
15.51	551477	341103.430	104.4	-0142	27819.8250	
15.52	552037	341234.077	344.7	-0144	27819.8171	

NO. 000000 043.07-100 JUNE 6 1967

G.I.I. NO. MIN	PRINGS	LT. TIME MICRO S	TIME APX MICRO S	T.C. MILLIGAL	S. VALU MILLIGAL	NOTE
17.45	574077	340764.236	394.2	-0.0206	97819.8174	
17.46	577447	340495.204	305.3	-0.0207	97819.8184	
17.47	572539	340146.027	104.5	-0.0209	97819.8471	
17.50	572941	344091.420	450.4	-0.0210	97819.8264	
17.52	573537	345266.307	456.1	-0.0210	97819.8282	
17.54	574091	345347.407	237.5	-0.0210	97819.8135	
17.46	574670	345564.236	394.2	-0.0211	97819.8159	
17.55	572171	344716.144	227.0	-0.0209	97819.8220	
17.57	569306	342422.479	496.4	-0.0210	97819.7824	
17.59	564031	343322.029	476.3	-0.0210	97819.8331	

*C DONALD 335., TEXAS JUNE 5 1980

C.M.T. HR. MIN	N. FRINGES	TUT. TIME MICRO S	TIME APEX MICRO S	T.C. MILLIGAL	C. VALUE MILLIGAL	NOTE
20.40	570450	384140.571	422.5	-.0179	978419.8129	
20.42	571498	384490.017	440.6	-.0174	978419.8329	
20.44	569358	383941.281	413.0	-.0173	978419.8432	
20.46	565228	382374.934	334.0	-.0170	978419.8737	
20.74	565295	382735.754	402.5	-.0168	978419.8057	
20.49	572137	384704.795	329.0	-.0165	978419.8380	
20.51	569130	383052.144	249.0	-.0161	978419.8520	
20.52	559214	383722.149	296.4	-.0159	978419.8310	
20.54	568333	383440.721	426.1	-.0156	978419.8372	
20.55	552543	381405.670	341.4	-.0154	978419.8382	

NO. 000000 035.0 TEXAS JUNE 5 1960

CALC. PER. MIN	NO. READING	INT. TIME MICRO S	TIME APPEX MICRO S	T.C. MILLICAL	G. VALUE MILLICAL	NOTE
21.35	57.777	384543.870	450.9	-.0050	978819.8405	
21.38	560824	380422.484	431.1	-.0490	978819.7353	
21.40	562953	381604.559	350.3	-.0043	978819.8293	
21.45	555535	382496.129	449.7	-.0029	978819.8737	
21.47	570083	384013.741	447.4	-.0022	978819.8503	
21.49	557259	379649.927	360.8	-.0016	978819.8279	
21.50	561799	381210.293	363.3	-.0013	978819.8735	
21.52	563471	381773.822	432.0	-.0006	978819.8547	
21.57	554813	378835.329	452.4	.0010	978819.8528	
21.58	562459	381572.684	179.0	.0013	978819.8623	
22.00	554402	382025.495	376.0	.0020	978819.8045	
22.02	557039	379594.917	322.6	.0026	978819.8207	
22.04	555954	381246.527	300.3	.0033	978819.8201	

MC DONALD CAS., TEXAS JUNE 7 1980

W.T. HR. MIN	N. FRINGES	TOT. TIME MICRO S	TIME APEX MICRO S	T.C. MILLIGAL	S. VALUE MILLIGAL	NOTE
13.26	554420	378701.754	506.3	.0185	478819.7308	
13.28	543108	376539.525	319.3	.0596	478819.7403	
13.29	544146	375103.524	377.5	.0602	478819.8191	
13.31	541759	374252.553	453.0	.0612	478819.7837	
13.33	543503	374954.413	497.7	.0621	478819.8164	
13.37	533447	372165.224	262.2	.0640	478819.4358	
13.38	535919	372353.510	350.3	.0650	478819.8304	
13.41	532000	370984.554	444.2	.0659	478819.7944	
13.43	534255	371751.988	469.9	.0668	478819.8416	
13.49	551645	377753.022	420.4	.0697	478819.8666	
13.50	539401	373537.038	430.4	.0702	478819.8395	
13.52	532421	371112.057	159.5	.0711	478819.7911	

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1. The first group of variables includes the following:

- β_1 : The intercept term, representing the expected return when all other variables are zero.
- β_2 : The coefficient for the market return, representing the market beta.
- β_3 : The coefficient for the size variable, representing the size beta.
- β_4 : The coefficient for the book-to-market ratio, representing the book-to-market beta.
- β_5 : The coefficient for the momentum variable, representing the momentum beta.
- β_6 : The coefficient for the profitability variable, representing the profitability beta.
- β_7 : The coefficient for the leverage variable, representing the leverage beta.
- β_8 : The coefficient for the industry effect, representing the industry beta.
- β_9 : The coefficient for the time effect, representing the time beta.
- β_{10} : The coefficient for the interaction term between size and book-to-market ratio.
- β_{11} : The coefficient for the interaction term between size and momentum.
- β_{12} : The coefficient for the interaction term between size and profitability.
- β_{13} : The coefficient for the interaction term between size and leverage.
- β_{14} : The coefficient for the interaction term between size and industry effect.
- β_{15} : The coefficient for the interaction term between size and time effect.
- β_{16} : The coefficient for the interaction term between book-to-market ratio and momentum.
- β_{17} : The coefficient for the interaction term between book-to-market ratio and profitability.
- β_{18} : The coefficient for the interaction term between book-to-market ratio and leverage.
- β_{19} : The coefficient for the interaction term between book-to-market ratio and industry effect.
- β_{20} : The coefficient for the interaction term between book-to-market ratio and time effect.
- β_{21} : The coefficient for the interaction term between momentum and profitability.
- β_{22} : The coefficient for the interaction term between momentum and leverage.
- β_{23} : The coefficient for the interaction term between momentum and industry effect.
- β_{24} : The coefficient for the interaction term between momentum and time effect.
- β_{25} : The coefficient for the interaction term between profitability and leverage.
- β_{26} : The coefficient for the interaction term between profitability and industry effect.
- β_{27} : The coefficient for the interaction term between profitability and time effect.
- β_{28} : The coefficient for the interaction term between leverage and industry effect.
- β_{29} : The coefficient for the interaction term between leverage and time effect.
- β_{30} : The coefficient for the interaction term between industry effect and time effect.

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GRAT FALLS, MD JUNE 17, 1960

S.M.T. H2.MIN	N. FRINGES	TOT. TIME MICRO S	TIME APX MICRO S	C. MILLIGAL	S. VALUE MILLIGAL
16.23	563433	371457.643	475.3	-0.6414	980497.1354
16.24	563553	371461.143	225.3	-0.6412	980497.2174
16.25	565413	372110.277	369.3	-0.6410	980497.1347
16.27	567018	372262.440	395.3	-0.6406	980497.2277
16.28	564156	372257.459	482.0	-0.6404	980497.2072
16.30	562556	372125.951	143.4	-0.6400	980497.2540
16.31	564856	372526.255	412.3	-0.6398	980497.2544
16.33	567435	372425.200	211.3	-0.6393	980497.2164
16.34	563135	372543.070	343.2	-0.6391	980497.2487
16.35	565273	372642.570	510.3	-0.6388	980497.2346
16.37	565536	372753.167	440.4	-0.6384	980497.2503
16.38	565056	372597.750	261.3	-0.6382	980497.2027
16.39	561932	372547.933	315.3	-0.6379	980497.2032
16.40	563606	372099.597	443.7	-0.6377	980497.2361
16.42	560394	372002.312	411.4	-0.6372	980497.1963
16.43	562216	372624.547	314.7	-0.6370	980497.2203
16.44	563114	372214.449	340.3	-0.6367	980497.2471
16.45	565457	372377.437	450.3	-0.6365	980497.2323
16.46	563712	372137.325	335.1	-0.6362	980497.1451
16.48	567393	372471.407	277.5	-0.6357	980497.2314
16.50	563705	372743.221	471.1	-0.6353	980497.1747
16.51	565933	372531.041	250.4	-0.6349	980497.1950
16.53	563406	372491.047	145.0	-0.6344	980497.1743
16.54	567313	372114.409	324.0	-0.6342	980497.1454
16.55	565903	372425.416	245.4	-0.6339	980497.2073
16.57	563075	372226.265	447.0	-0.6333	980497.1743

GREAT FALLS, N.D. JUNE 17 1926

G.M.T. HR. MIN	N. FRINGES	ULI. TIME MICRONS	TIME APERTURE MICRONS	I.C. MILLIGAL	C. VALU MILLIGAL
16.59	539129	375105.099	326.7	-.0329	980497.1572
17.00	545032	375504.377	444.7	-.0325	980497.1301
17.01	544225	376257.744	224.3	-.0323	980497.2795
17.05	545739	375747.374	445.4	-.0309	980497.1596
17.07	542914	374430.454	60.4	-.0306	980497.2170
17.09	546070	375514.313	285.1	-.0300	980497.2443
17.10	550767	377126.354	353.4	-.0297	980497.2263
17.11	549712	376757.043	455.3	-.0294	980497.2254
17.14	545342	375435.490	425.0	-.0286	980497.2006
17.16	545645	375372.356	501.6	-.0279	980497.2262
17.18	544995	375147.528	453.5	-.0273	980497.1619
17.19	542220	374191.167	405.6	-.0270	980497.7006
17.20	544659	375031.913	420.7	-.0267	980497.2470
17.22	546524	375573.236	105.3	-.0261	980497.2090
17.25	548711	376424.251	321.6	-.0251	980497.2419
17.26	547497	376007.700	402.1	-.0249	980497.2132

N.V.I.

GREAT FALLS, MD JUNE 17 1940

G.M.T. HR. MIN	N. FRINGES	TOT. TIME MICRO S	TIME APEX MICRO S	T.C. MILLIGAL	S. VALU MILLIGAL
20.30	564782	371897.075	425.3	.0441	980497.2006
20.31	556901	372223.133	337.0	.0444	980497.1374
20.32	559951	380263.539	337.7	.0447	980497.2553
20.33	557480	380100.265	413.7	.0450	980497.2531
20.34	555852	378365.864	414.7	.0453	980497.2349
20.41	556618	379126.871	455.3	.0475	980497.2384
20.42	548426	375633.524	460.1	.0479	980497.1854
20.45	553254	377979.468	432.9	.0488	980497.1780
20.46	550178	376927.173	377.9	.0491	980497.2503
20.47	548250	376266.197	369.4	.0433	980497.2352
20.49	551503	377380.686	256.4	.0499	980497.2327
20.51	554377	379362.830	376.4	.0514	980497.1071
20.54	550358	376485.498	493.3	.0513	980497.0924
20.55	548815	376459.416	285.4	.0515	980497.2372
20.56	547439	375987.780	351.9	.0518	980497.1944
20.58	547796	376110.276	241.4	.0524	980497.1497
21.00	546145	375543.249	460.5	.0529	980497.1191
21.04	543499	376351.791	318.3	.0539	980497.2175
21.07	555839	378861.456	423.5	.0544	980497.1780
21.09	553033	377903.488	358.3	.0551	980497.1424
21.11	549213	376546.413	325.3	.0555	980497.3270
21.13	547630	376739.237	41.0	.0561	980497.2444
21.15	551755	377466.436	305.4	.0566	980497.2322
21.19	547125	376566.364	411.3	.0574	980497.1304
21.20	551253	377295.190	309.4	.0574	980497.1027
21.21	545977	375929.207	450.4	.0574	980497.1421
21.23	554174	378299.251	241.0	.0592	980497.2377
21.24	551521	377347.091	450.2	.0594	980497.1113
21.26	549279	376522.493	351.5	.0594	980497.1427
21.30	546502	376865.790	399.0	.0594	980497.1427
21.32	551173	377257.490	477.7	.0594	980497.2372
21.54	543351	375304.275	402.0	.0594	980497.1721

GREAT FALLS, MO JUNE 17 1980

G.M.T. HR. MIN	N. FRINGES	TOT. TIME MICRO S	TIME APEX MICRO S	T.C. MILLIGAL	S. VALUF MILLIGAL	NOTE
22.10	545090	375140.267	385.9	.0645	980497.1522	N.V.T. REC.
22.12	554720	375479.771	204.4	.0647	980497.2253	
22.13	551630	377427.162	152.5	.0648	980497.2319	
22.16	54393	376518.615	349.0	.0649	980497.2296	
22.20	5505	377066.056	90.4	.0650	980497.2405	
22.21	55114	377244.257	337.3	.0651	980497.2717	
22.23	555840	376861.598	523.0	.0651	980497.1840	
22.26	563021	381301.305	484.3	.0652	980497.1970	
22.27	562448	381107.216	430.5	.0652	980497.2242	

GREAT FALLS, MO JUNE 13 1930

G.M.T. HR. MIN	N. FRINGES	TOT. TIME MICRO S	TIME APEX MICRO S	T.C. MILLIGAL	G. VALUE MILLIGAL	NOTE
15.45	574104	385035.827	338.0	.0357	980497.2105	
15.47	568175	383042.313	197.3	-.0355	980497.1505	
15.50	567977	382975.662	352.3	-.0355	980497.2238	
15.51	570948	383975.923	252.8	-.0355	980497.2086	
15.55	563942	383301.013	492.2	-.0353	980497.2502	
15.58	565231	382048.671	252.8	-.0352	980497.2453	
16.01	564152	381683.973	410.6	-.0350	980497.2674	
16.05	565779	382233.957	409.2	-.0348	980497.2539	
16.07	567992	382980.513	229.7	-.0347	980497.2551	
16.10	560432	380423.598	506.0	-.0345	980497.2956	
16.15	564162	381687.255	298.4	-.0342	980497.2507	

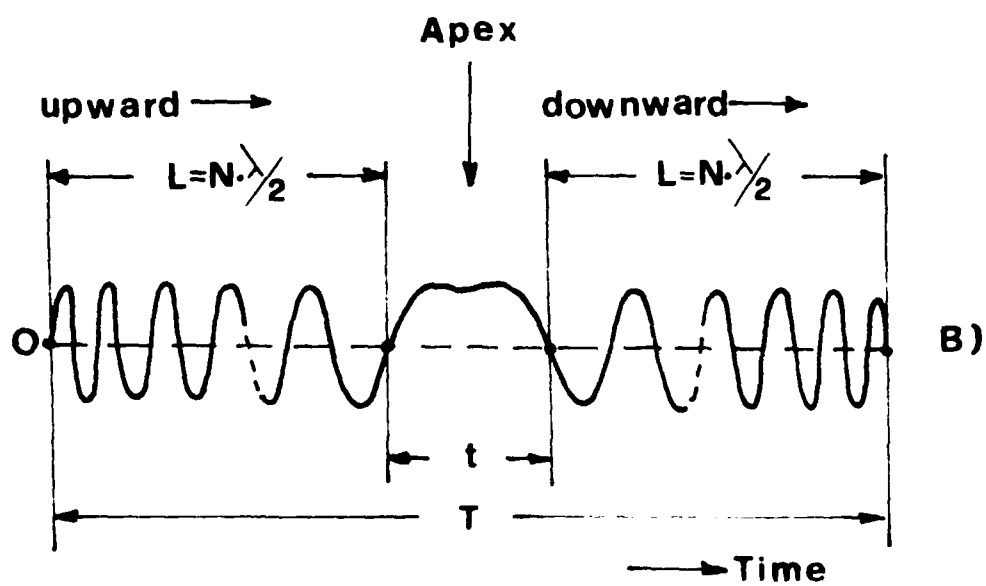
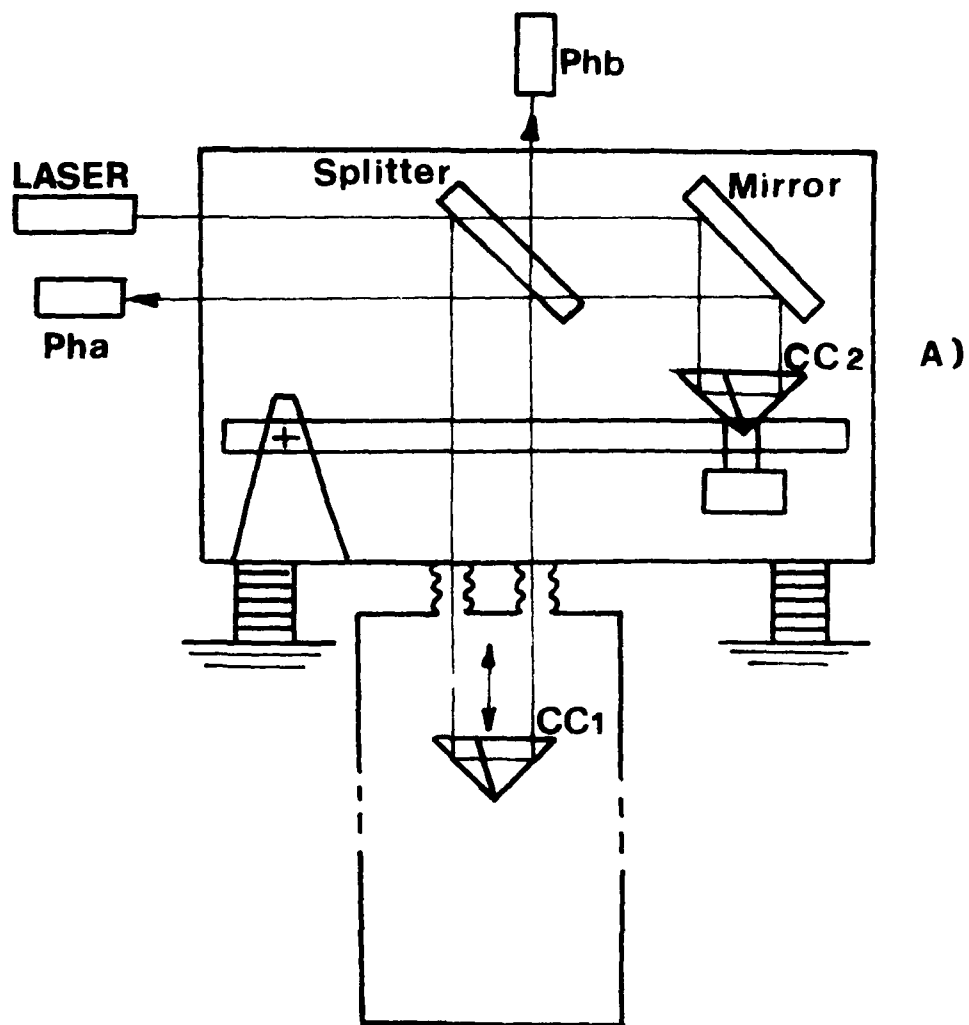
N.I.T. S.S.

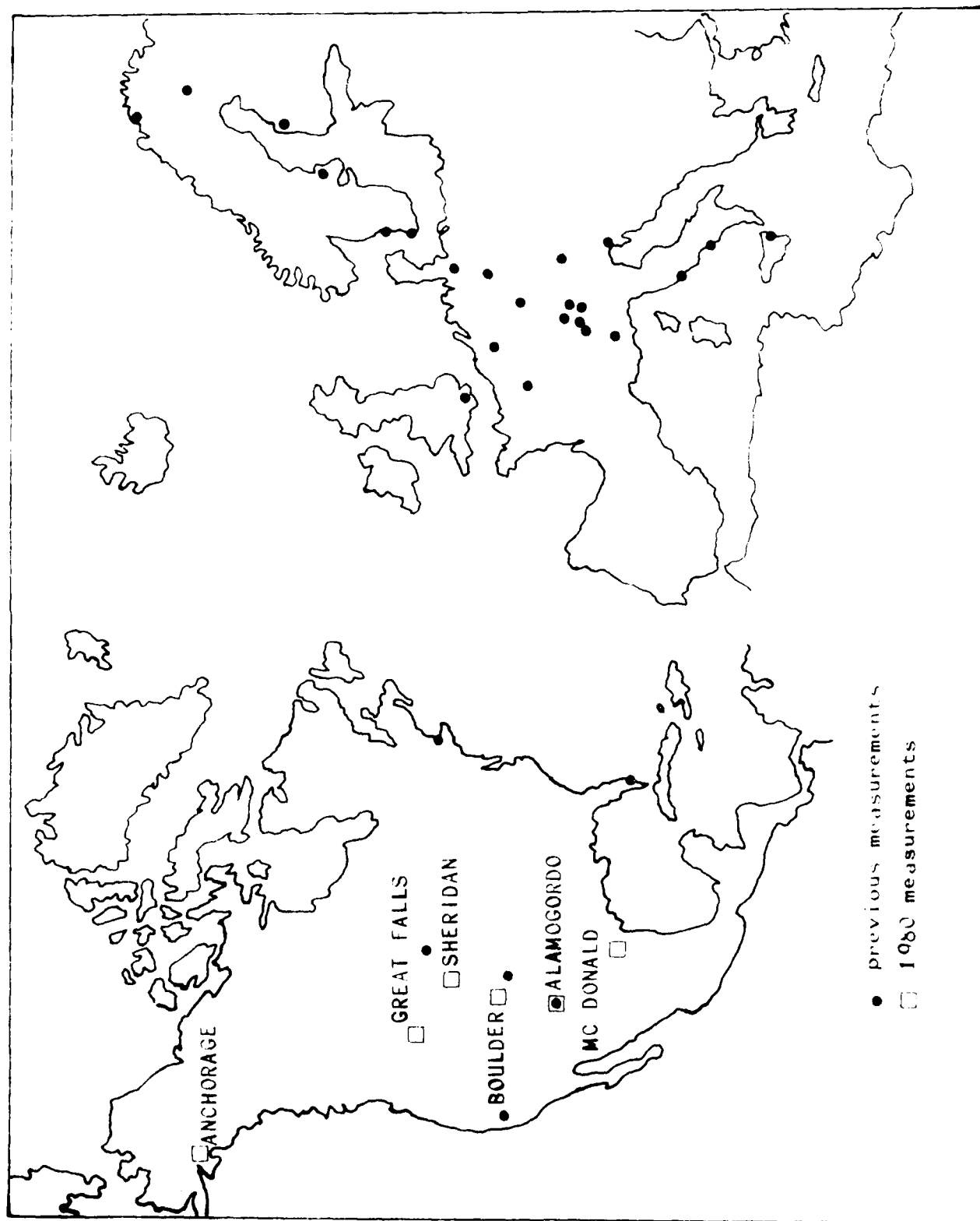
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ALASKA - JUNE 28 1930

STATION	TIME	TEMP. ADJ.	T.C. MILLIGAL	T.C. MILLIGAL
17.000	17.000	471.4	-0.0250	0.1324.444
17.000	17.000	477.2	-0.0240	0.1324.4741
17.000	17.000	477.7	-0.0230	0.1324.4813
17.000	17.000	480.0	-0.0220	0.1324.4874
17.000	17.000	484.2	-0.0210	0.1324.4936
17.000	17.000	484.4	-0.0200	0.1324.4997
17.000	17.000	489.6	-0.0190	0.1324.5058
17.000	17.000	489.8	-0.0184	0.1324.5119
17.000	17.000	494.1	-0.0175	0.1324.5180
17.000	17.000	494.3	-0.0170	0.1324.5241
17.000	17.000	495.4	-0.0160	0.1324.5302
17.000	17.000	496.6	-0.0150	0.1324.5363
17.000	17.000	497.4	-0.0140	0.1324.5424
17.000	17.000	498.6	-0.0135	0.1324.5485
17.000	17.000	499.8	-0.0130	0.1324.5546
17.000	17.000	500.0	-0.0125	0.1324.5607
17.000	17.000	501.2	-0.0120	0.1324.5668
17.000	17.000	502.4	-0.0115	0.1324.5729
17.000	17.000	503.6	-0.0110	0.1324.5790
17.000	17.000	504.8	-0.0105	0.1324.5851
17.000	17.000	506.0	-0.0100	0.1324.5912
17.000	17.000	507.2	-0.0095	0.1324.5973
17.000	17.000	508.4	-0.0090	0.1324.6034
17.000	17.000	509.6	-0.0085	0.1324.6095
17.000	17.000	510.8	-0.0080	0.1324.6156
17.000	17.000	512.0	-0.0075	0.1324.6217
17.000	17.000	513.2	-0.0070	0.1324.6278
17.000	17.000	514.4	-0.0065	0.1324.6339
17.000	17.000	515.6	-0.0060	0.1324.6400
17.000	17.000	516.8	-0.0055	0.1324.6461
17.000	17.000	518.0	-0.0050	0.1324.6522
17.000	17.000	519.2	-0.0045	0.1324.6583
17.000	17.000	520.4	-0.0040	0.1324.6644
17.000	17.000	521.6	-0.0035	0.1324.6705
17.000	17.000	522.8	-0.0030	0.1324.6766
17.000	17.000	524.0	-0.0025	0.1324.6827
17.000	17.000	525.2	-0.0020	0.1324.6888
17.000	17.000	526.4	-0.0015	0.1324.6949
17.000	17.000	527.6	-0.0010	0.1324.7010
17.000	17.000	528.8	-0.0005	0.1324.7071
17.000	17.000	530.0	0.0000	0.1324.7132





A P P E N D I X

GRAVITY STATION DESCRIPTION		STATION TYPE	STATION NUMBER
COUNTRY USA	STATE/PROVINCE Colorado	Absolute Site	Boulder, P.
LOCATION 40° 00.15' N	COORDINATE 105° 16.1' W	STATION	Boulder
GRAVITY STATION MARK Brass disk	AGENCY SOURCE USAF	STATION	10 meters
POSITION REFERENCE Map	POSITION SOURCE USGS 7 1/2'	STATION	Gravity station
ELEVATION REFERENCE Map	ELEVATION SOURCE USGS 7 1/2'	STATION	Boulder, Colo 1966
POSITION ELEVATION REMARKS			
<p>DESCRIPTION: The station is in the southern part of Boulder at the University of Colorado, 0.5 miles west of 26th Street, south of Colorado Avenue and Palmer Station, at the Joint Institute for Laboratory Astrophysics (JILA) building. Observations were made in the sub-basement in Room B0017 (the Spectroscopy Hall) near the northwest corner, 1.5 meters south of the north wall, 2.0 meter east of the west wall, on the tile floor.</p> <p>Reference: 15505P</p>			
<p>DATE OF PHOTO May 1980</p>			
NAME OF PHOTOGRAPHER W.G. Spitta		AGENCY DMAHTC/GSS	DATE May 1980

DMATC FORM 8250-2 (GSS) MAR 79

Supersedes DMATC FORM 8250-9 (GSS), Oct 77 which will be used until stock is exhausted.

GRAVITY STATION DESCRIPTION	Absolute Site	STATION NAME
COUNTRY USA	STATE New Mexico	Holloman A
CITY 32° 53.5' N	COUNTY 106° 06.0' W	Alamogordo
GRAVITY STATION MARK Brass Disk	AGENCY CODE DMA	ELEVATION 1250 meters
ELEVATION REFERENCE Map	ELEVATION USGS 15'	DATE OF ESTABLISHMENT Gravity Base
ELEVATION REFERENCE Map	ELEVATION USGS 15'	DATE OF ESTABLISHMENT Holloman, N.M. 1946
REMARKS contour interval = 25 feet		
<p>The station is about 8 miles west of Alamogordo at the north side of Holloman Air Force Base in the Advanced Inertial Test Laboratory (building 1256). Observations were made in the basement level in Room 10 (the northeastern most room of the basement), on the round concrete pier, midway between the center and the south edge of the pier.</p>		
ICF Code: 11926A		
<p>November 1977</p> <p>W. G. Spita</p> <p>DMATC/GSS</p> <p>November 1977</p>		

TPC FORM 115-20
MAY 77

REPLACES TEST EDITION, AUG 69, WHICH IS OBSOLETE

GRAVITY STATION DESCRIPTION		STATION TYPE	STATION DESIGNATION
COUNTRY: USA		Absolute Site	McDonald AB
LATITUDE: 30° 40' 13" N		STATE PROVINCE: Texas	CITY: Ft Davis
GRAVITY STATION MARK: None		LONGITUDE: 104° 01' 13" W	ELEVATION: 2065.6 meters
POSITION REFERENCE: Estimated from Trig. Sta		AGENCY SOURCE: NGS	INSCRIPTION: McDonald, 1942
ELEVATION REFERENCE: Spot elev. Engineer's Map		POSITION SOURCE: Univ. of Texas	SOURCE DESIGNATION: McDonald Observatory
POSITION ELEVATION REMARKS:			
<p>CI=2 feet, station is 100 meters NE of Trig. Station</p> <p>DESCRIPTION The station is 17 miles northwest of Ft. Davis on Mt. Locke at the McDonald Observatory. To reach from the courthouse in Ft. Davis go 15 miles northwest along Texas Highway 118, then turn right and go southeast 2 miles along Spur Road 78 to McDonald Observatory. The station is east of the top of the mountain, at the end of the road, in the 107 inch Telescope Building, ground level. Observations were made in the northeast side, in Room 103, 1.8 meter east of the west wall and door of the room and 1.1 meter south of the north wall, on the tile floor.</p> <p>GSS Code: 119S04</p>			
<p>DIAGRAM PHOTOGRAPH</p>			
DESCRIBED/RECOVERED BY: W.G. Spita		AGENCY: DMAHTC/GSS	DATE: June 1980

DMAHTC FORM 8250-9 (GSS) MAR 79

Supersedes DMAHTC FORM 8250-9 (GSS), Oct 77 which will be used until stock is exhausted.

GRAVITY STATION DESCRIPTION		STATION TYPE	STATION DESIGNATION
COUNTRY	U.S.A.	Absolute Site	Sheridan AB
STATE	Wyoming	STATE/PROVINCE	CITY
COORDINATE	44° 45.'6 N	LONGITUDE	1205 Meters
GRAVITY STATION MARK	Brass Disk	AGENCY SOURCE	INSRIPTION
POSITION REFERENCE	Map	POSITION SOURCE	SOURCE DESIGNATION
ELEVATION REFERENCE	Map	ELEVATION SOURCE	SOURCE DESIGNATION
POSITION ELEVATION REMARKS			
<p>CI= 20 Feet</p> <p>DESCRIPTION</p> <p>The station is about 2.5 miles south of the center of Sheridan, west of Wyoming Highway #333, at the Wyoming State Girls School, in Stolt Hall (Administration building). Observations were made in the basement, east of the boiler room, near the northeast corner of the large room used for arts and crafts, in a small storage room. The station is 1.0 meters north of the south wall of the room, 0.9 meters east of the west wall, 1.6 meters west of "AA" (the AFGL station), and 2.5 meters west of the disk, on the concrete floor.</p> <p>GSS Code: 155V04</p>			
<p>DIAGRAM PHOTOGRAPH</p> <p>The diagram consists of two parts. The top part is an 'INSET' map showing the location of the station relative to Stolt Hall, Wyoming State Girls School, and Highway #333. It indicates a 'Driveway' and a 'Parking' area, and notes the distance 'To Hwy #333 0.2 miles'. The bottom part is a larger diagram of the 'Stolt Hall Basement'. It shows the 'boiler room' and 'Arts and Crafts' room. The station is marked with a dot in the 'Arts and Crafts' room, near the 'boiler room'. A 'Walk' path and 'Driveway' are also indicated.</p>			
<p>Walter G. ...</p>		AGENCY	DATE
		DMAHTC/GSS	June 1980

DMATC FORM 8250-9 (125) MAR 79

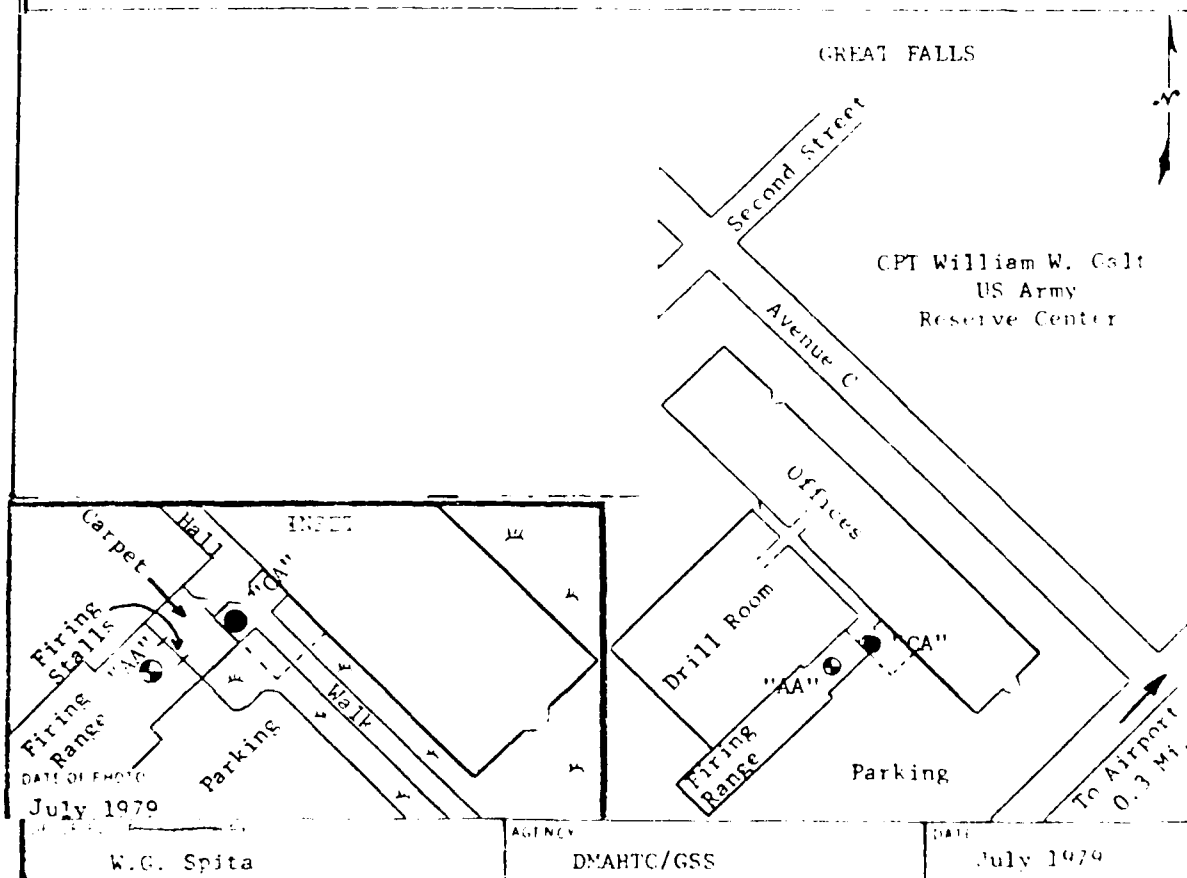
Supersedes DMATC FORM 8250-9 (GSS), Oct 77 which will be used until stock is exhausted.

GRAVITY STATION DESCRIPTION	STATION TYPE	STATION DESIGNATION
	Absolute Site	Great Falls AA
COUNTRY	STATE PROVINCE	CITY
U.S.A.	Montana	Great Falls
LATITUDE	LONGITUDE	ELEVATION
47° 28.'7 N	111° 21.'6 W	1120 Meters
GRAVITY STATION MARK	AGENCY SOURCE	INTERSECTION
Brass Disk	DMA	
POSITION REFERENCE	POSITION SOURCE	SOURCE DESIGNATION
Map	USGS 7 1/2'	1965 Southwest Great Falls, MT
ELEVATION REFERENCE	ELEVATION SOURCE	SOURCE DESIGNATION
Map	USGS 7 1/2'	1965 Southwest Great Falls, MT
POSITION ELEVATION REMARKS		

CI = 20 Feet

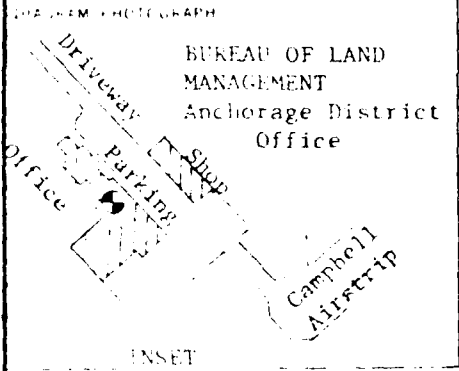
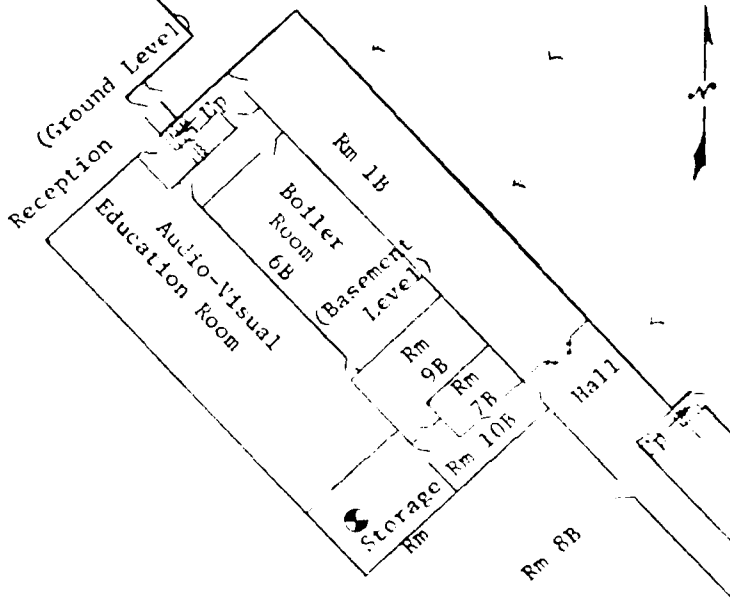
The station is at the west side of Great Falls on Gore Hill, south of the airport and at the south side of the intersection of Avenue C and Second Street, at the CPT William W. Galt US Army Reserve Center. Observations were made near the south side of the building in the firing range, northeast end, 1.5 meters southwest of the middle firing stall (also 1.5 meters from edge of carpet). The station is midway between the northwest and southeast walls, 2.0 meters southeast of the disk, on the concrete floor.

GSS Code: 156E05



DMAHC FORM 8250-9 (GSS)
OCT 77

Supersedes GSSQ FORM 8250/QD-9, May 75 which is obsolete.

GRAVITY STATION DESCRIPTION	STATION TYPE Absolute Site	STATION DESIGNATION Anchorage AA
COUNTRY USA	STATE PROVINCE Alaska	CITY Anchorage
LATITUDE 61° 09.'37N	LONGITUDE 149° 47.'56W	ELEVATION 70 meters
GRAVITY STATION MARK Aluminum Disk	AGENCY SOURCE USGS	INSCRIPTION
POSITION REFERENCE Map	POSITION SOURCE USGS 1:25,000	SOURCE DESIGNATION Anchorage (A-8) NE, 1979
ELEVATION REFERENCE Map	ELEVATION SOURCE USGS 1:24,000	SOURCE DESIGNATION Anchorage & Vicinity, 1961
POSITION ELEVATION REMARKS CI=20 feet The station is at the southeast side of Anchorage, about 0.5 miles southeast of the intersection of East 68th Avenue and Abbott Loop Road, at the Bureau of Land Management Anchorage District Office. Observations were made in the office building, in the basement, westside, in the storage room which is southeast of the Audio-Visual Education Room and southwest of Room 10B (a hallway). The station is 1.3 meters northeast of the southwest wall of the room and 1.6 meters southeast of the north-west wall, on the concrete floor.		
GSS Code: 231A01		
		
		
DATE OF PHOTOGRAPH		
DATE OF PHOTOGRAPH		
AGENCY DMAHTC /GSS		DATE June 1980

DMAHTC FORM 8250-9 (GSS) MAR 79

Superseries DMAHTC FORM 8250-9 (GSS), Oct 77
which will be used until stock is exhausted.

